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Technical Report

No. 13323

ADVANCED DEVELOPMENT

WASTE PROCESSING UNIT FOR COMBAT VEHICLES

(PHASE II)

CONTRACT NUMBER DAAE07-86-C-R089

DECEMBER 1987

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By _____

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U.S. ARMY TANK-AUTOMOTIVE COMMAND
RESEARCH, DEVELOPMENT & ENGINEERING CENTER
Warren, Michigan 48397-5000

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This advanced development was initiated to develop a prototype Waste Processing Unit (WPU) to evaluate the concept of on-board processing of human waste generated within a combat vehicle operating in an NBC environment.

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1.0. INTRODUCTION

This final technical report was prepared by OLIS Engineering, a division of OLIS Enterprises, Inc., for the U.S. Army Tank-Automotive Command (TACOM) under Contract DAAE07-86-C-R089. It describes the Phase II development effort which was performed to produce the prototype hardware to dispose of human waste generated within combat vehicles while operating in a nuclear, biologically, or chemically (NBC) contaminated environment. The work performed resulted in the development of a waste processing unit for use in combat vehicles as well as a prototype of a waste processing system for marine applications.

2.0. OBJECTIVE

The primary objective of Phase II of this research was to produce a waste disposal system for combat vehicles operating in an NBC contaminated environment. A system was needed which will safely and efficiently process and dispose of the human waste generated within the confines of a combat vehicle operating under conditions which prohibit opening the vehicle to dispose of the generated waste. As space, power, and water are extremely limited in the types of vehicles under consideration, concepts were defined which require a minimum of those commodities under Phase I of this research. While developing a viable waste disposal system for this specific application, it was also a goal of this research to define and develop a waste processing system for various marine applications as a possible commercial application of the concept.

3.0. CONCLUSIONS

The work performed under Phase II of this contract has resulted in the design and fabrication of a system capable of the efficient disposal of human waste from within a combat vehicle operating in an NBC environment with minimum impact to the vehicle or to the personnel operating within that vehicle. The Waste Processing Unit (WPU) has been demonstrated both by analysis and testing. The WPU for combat vehicle is currently undergoing further testing at Aberdeen Proving Grounds. Additionally, a modified version of the WPU was fabricated and tested to verify the feasibility of adapting the concept to marine applications. This effort has proven the feasibility of the application, and appears to have significant commercial possibilities.

4.0. RECOMMENDATIONS

4.1. Installation

Installation of the WPU into a combat vehicle should be accomplished by the addition of a bypass exhaust system to the existing engine exhaust system. The bypass exhaust system should include a cutout valve for activating or deactivating the system, and a check valve at the final exhaust line from the WPU.

4.2 Waste Disposal Port Seal

Depending on the application, the seals at the Waste Disposal Port drum should be modified by the addition of another seal positioned in such a manner as to provide a more effective seal around the drum.

5.0. DISCUSSION

5.1. Description of Work

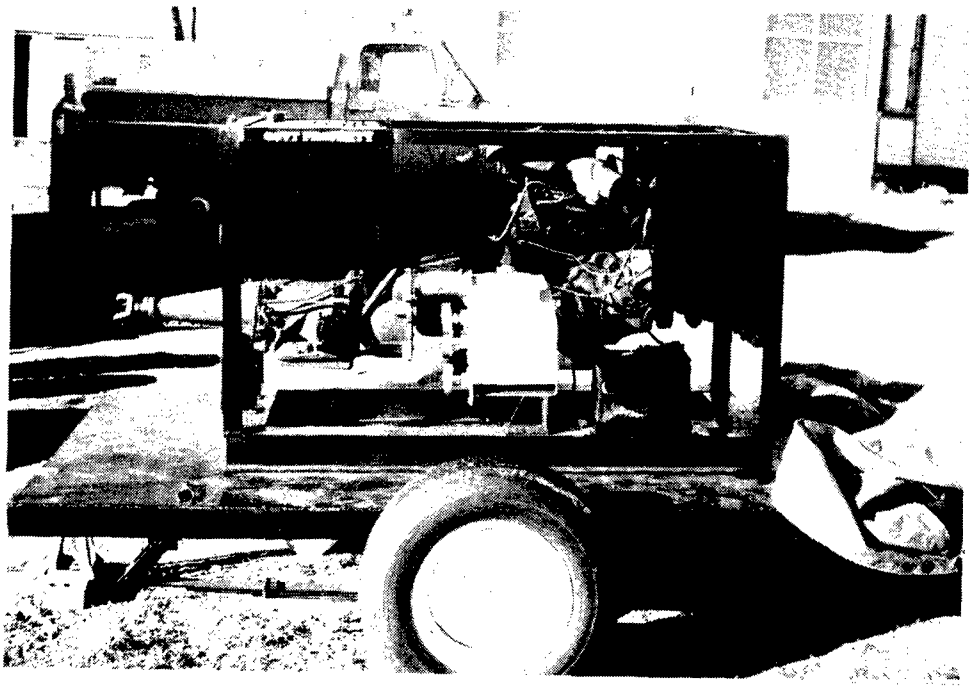
To develop a viable vehicle waste disposal system for combat vehicles operating in an NBC contaminated environment, the following work was performed.

5.1.1. WPU Test Stand. A facility for the testing of the WPU bench model and development units was designed and fabricated. The WPU test stand consisted of an automotive-type six-cylinder gasoline engine with all necessary ancillary equipment required to maintain controlled operation of the engine. The engine exhaust manifold was modified with a fitting for the attachment of the WPU's testing. The entire assembly was mounted on a stand permitting relocation of the unit when it was not in use. A collection tray was also provided to collect effluents from the WPU for analysis. A photograph of the WPU test stand is shown in Figure 5-1.

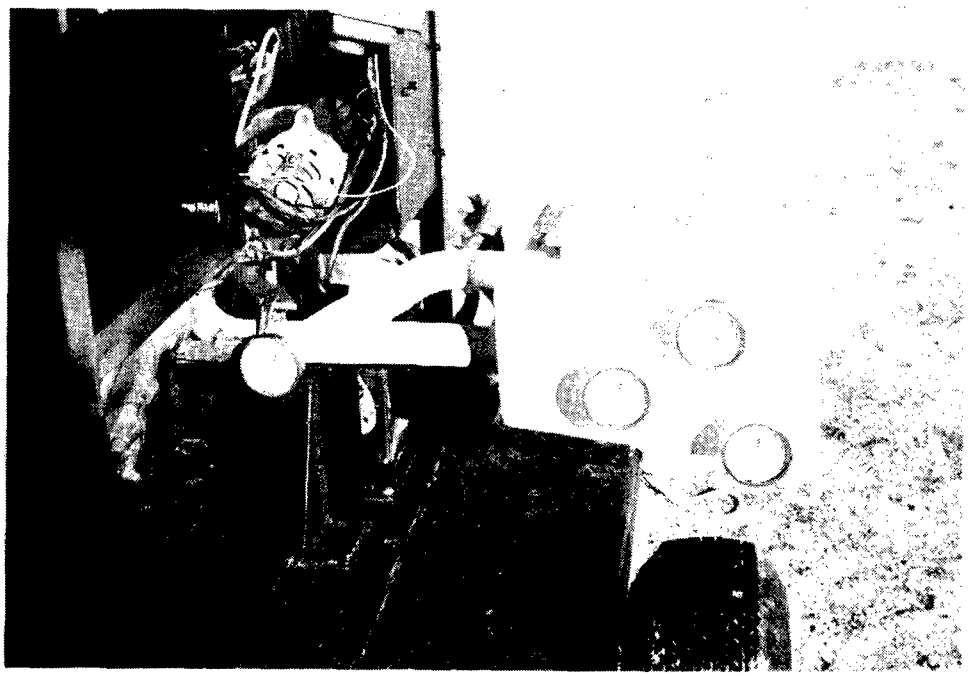
5.1.2. Bench Model Testing. Following the completion of the WPU test ttand, the WPU bench model #WPU-BM001 was modified as shown in Figure 5-2 and tested in accordance with the WPU Bench Model Test Procedure #OEI-BM001. The bench model testing obtained specific parameters pertinent to the optimization of the WPU design, and included the operating temperatures in various regions within the WPU, effects of insulation on internal temperatures, minimum operational inlet temperature, average cycle time as a function of inlet temperature, effluent properties and quantities, etc.

5.1.3. WPU Development Unit. Based on the results of the bench model testing, the WPU development unit was designed specifically to fit within the confines of the Concept Command Post Vehicle (CCPV), and was powered by a portion of the exhaust from the main engine of that vehicle. Specific limitations on the design included the available volume within the compartment in the CCPV allocated for the WPU. A photograph of the basic WPU development unit is shown in Figure 5-3.

5.1.4. Waste Disposal Port. A waste disposal port for the transferring of waste from the interior of the CCPV to the WPU was designed. The Waste Disposal Port (WDP) was designed so as to permit waste to be placed into the WPU directly from the Pacto toilet currently in the CCPV without danger of compromising the interior of the vehicle. An interlock should be provided to prevent opening of the WDP unless the main engine is operating. Several concepts were developed and evaluated; the best concept for this application was fabricated for use on the CCPV. The WDP uses a rotary valve integral to the top of the WPU. Other approaches that were investigated included variations of incineration dump chutes used in the past in multistory apartment buildings.



(a) Side View



(b) WPU Bench Model Installed

Figure 5-1. WPU Test Stand

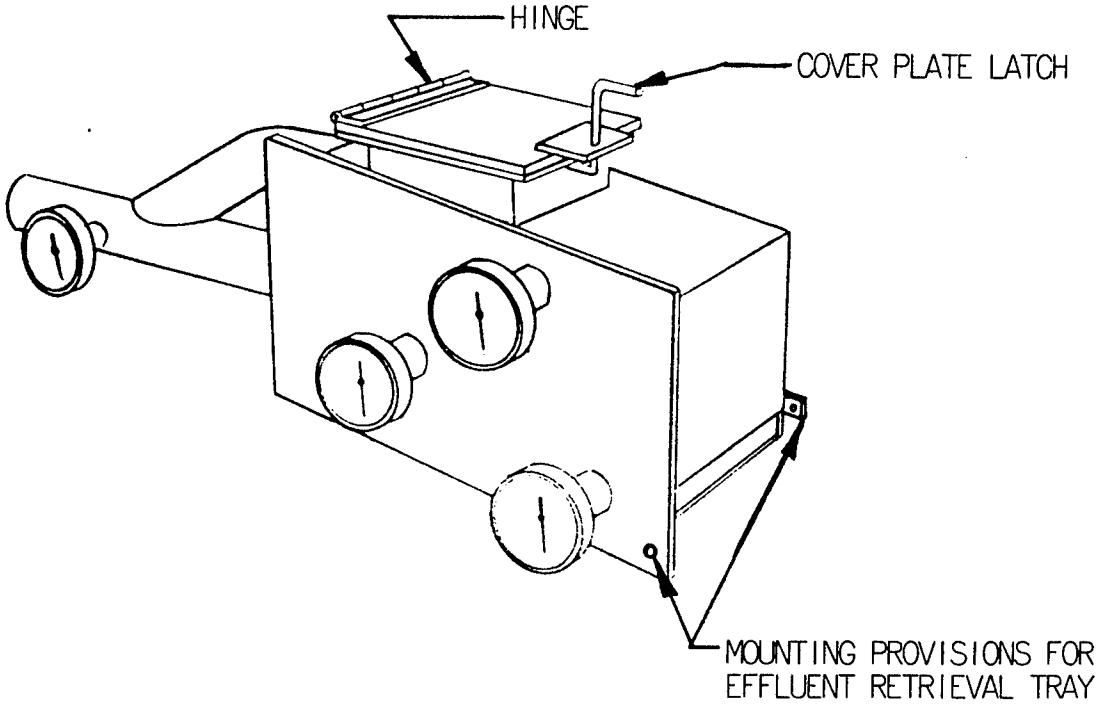
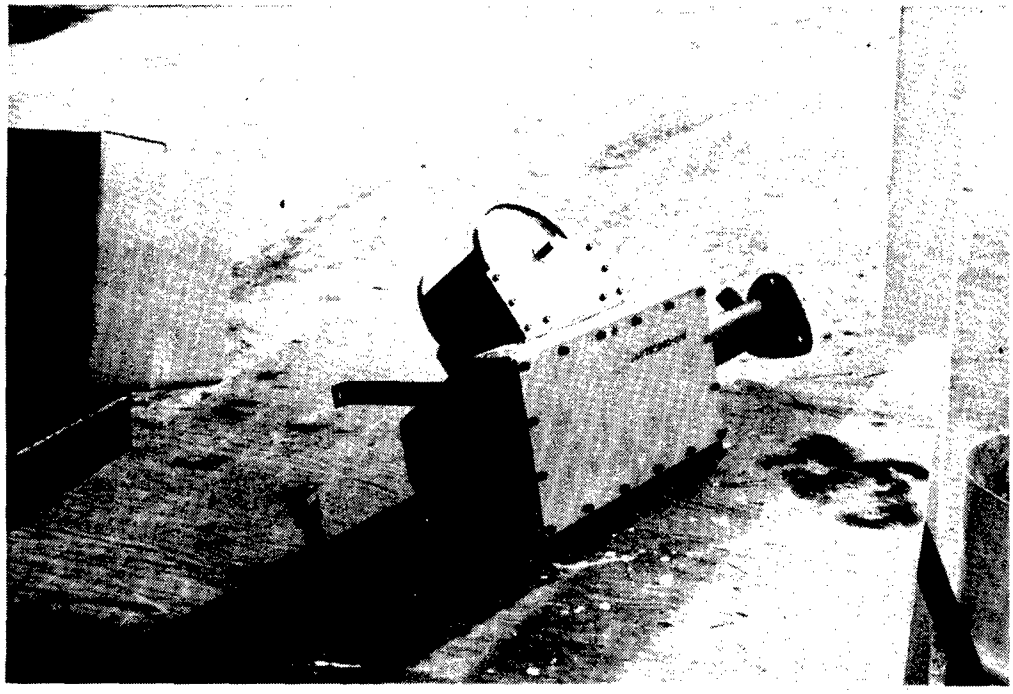
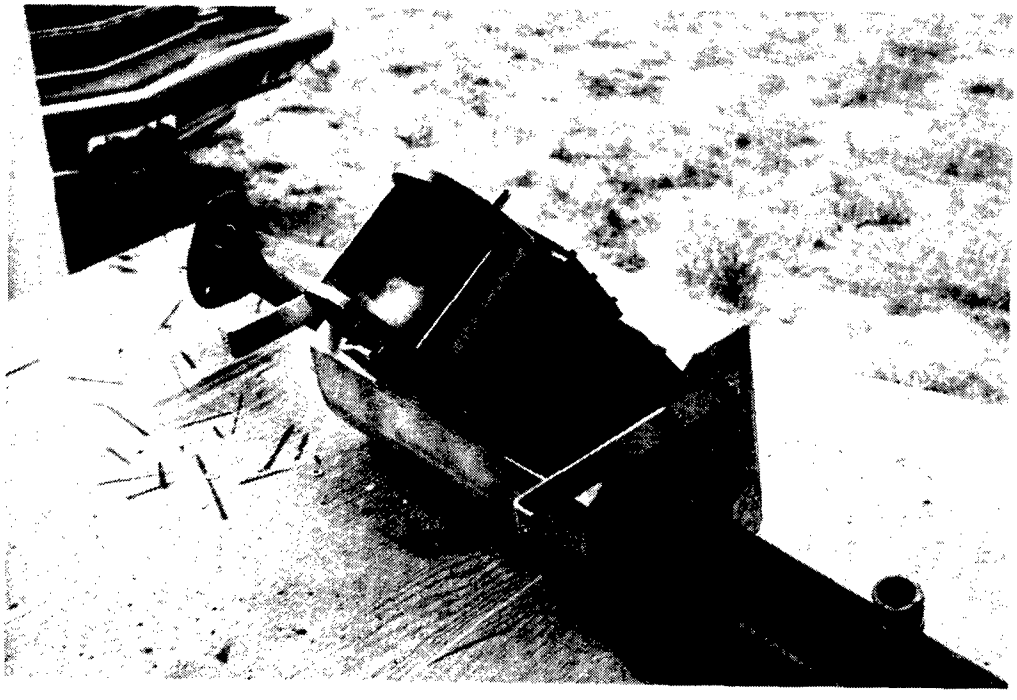


Figure 5-2. WPU Bench Model Modifications



(a) Front view, looking from WPU Outlet



(b) Top View, showing WDP

Figure 5-3. WPU Development Unit

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5.1.5. Marine WPU. A WPU development unit was designed for the specific application of processing waste from a marine head. This unit was quite similar to the standard WPU, but was mounted so as to permit flushing water to flow through the unit and out the exhaust pipe, while trapping the solid waste for incineration by the engine exhaust. A diagram of the Marine WPU development unit is shown in Figure 5-4.

5.1.6. Development Model Fabrication. The WPU development unit for the CCPV, the WDP, and the Marine WPU development unit were fabricated. Primary material was corrosion resistant (stainless) steel. The development units differed from operational units only in that they had removable adaptors for attachment onto the WPU test stand.

5.1.7. Development Model Testing. The WPU development units and the WDP were tested under simulated actual operating conditions using the WPU test stand, and a modified form of the WPU Bench Model Test Procedure #OEI-BM001.

5.1.8. Operation Manual. A manual was to be prepared to clearly describe all aspects of the operation and maintenance of the WPU, but this will be deferred pending completion of the testing of the WPU at Aberdeen Proving Grounds.

5.1.9. WPU Development Unit Refurbish. The WPU development unit and the WDP for the CCPV were refurbished as required and prepared for installation into the CCPV for further testing.

5.1.10. WPU/WDP Installation. The principal investigator accompanied the refurbished WPU and WDP to Aberdeen Proving Grounds to assist TACOM personnel in the installation of the units into the concept Command Post Vehicle, and participated in the checkout of the units after installation.

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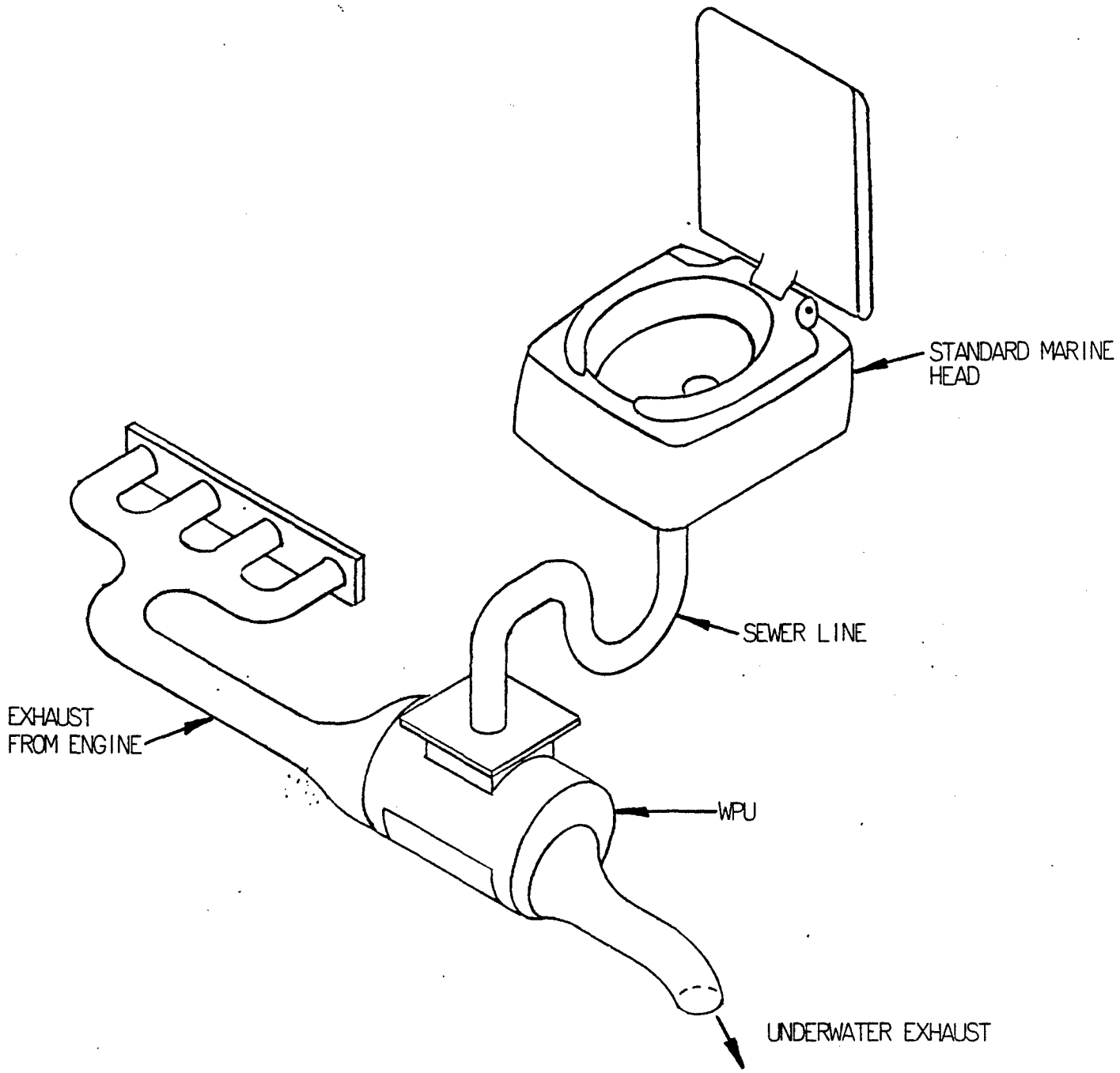

Figure 5-4. Marine WPU Concept

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5.2 Project Results

Although final results of the field testing of the WPU Development Unit at Aberdeen Proving Grounds is not yet available, preliminary test results indicate that the WPU may prove suitable for combat vehicle applications. A summary of the overall project results and conclusions follows.

5.2.1. WPU. A development model of the WPU was designed and fabricated for advanced testing. The unit was constructed entirely of stainless steel, and was designed to fit within the confines of the waste storage compartment under the Pacto toilet in the CCPV. A WDP was incorporated in the top of the WPU, and employs a sealed and insulated rotating drum to deliver the waste to the WPU. Inlet and outlet flanges were provided to permit attaching the WPU to a bypass exhaust system from the vehicle's main engine. A front cover assembly, including the necessary hardware for mounting the operating handle, was also fabricated. The WPU was tested at Olis Engineering, where it was determined that the unit was effective at processing human waste to a light, dry ash using only internal combustion engine exhaust as a power source. For differing applications, modifications to the WDP sealing system may be desired. Following the development testing at Olis Engineering, the WPU and WDP were refurbished to like-new condition and delivered to Aberdeen Proving Grounds for further testing and evaluation.

5.2.2. Marine WPU. The original WPU bench model was modified extensively for the specific purpose of evaluating the feasibility of developing a WPU for marine applications. It was determined that if the objectionable odor associated with the incineration of the waste material could be minimized, a potential commercial application for the WPU would be various types of smaller marine craft, especially those operating in inland and coastal waters. In order to verify the premise that exhausting the outflow from the WPU under water would reduce the odor to an acceptable level, and to verify satisfactory operation of the WPU when flush water was used to deliver the waste material to the unit, a marine WPU development unit was constructed around the original WPU bench model. Testing of this unit at Olis Engineering indicated that not only did the concept work, but that odors were reduced to a level as to be essentially undetectable. The concept of using a standard collection and delivery system (i.e., standard flushing toilet connected to standard plumbing delivers the waste to the WPU) proved to be most effective. It was determined, however, that a flapper valve should be included in the design at the WPU to prevent backflow of exhaust into the plumbing and toilet when there is insufficient water in the trap to prevent backflow.

5.2.3. Conclusions. This research has resulted in the definition of two systems for effectively processing human waste using waste heat and gas flow resulting from vehicle engine exhaust. While specific applications will require modifications to the system, the basic WPU has been proven effective at reducing human waste material to a harmless black ash, which is expelled from the system as the vehicle engine supplies exhaust to the unit. Promising commercial applications have been identified, and are being pursued. The necessary steps for protecting the concept have been taken, and patent application is pending.

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Lord, C.K., "Background Data Report for Concept Study - Vehicle Waste Disposal System", OLIS Engineering, Sedalia, CO (1985)

Lord; C.K., "Concept Study - Vehicle Waste Disposal System", U.S. Army Tank Automotive Command RD&E Technical Report #13155, U.S. Army Tank-Automotive Command, Warren, MI 48397-5000 (1986)

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APPENDIX A

WPU BENCH MODEL TESTS

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ENGINEERING DEVELOPMENT TEST:

WASTE PROCESSING UNIT BENCH MODEL TEST PROCEDURE

#OEI - BM001

TEST DATE: start 86-11-14
complete 86-12-5

TEST CONDUCTOR: James A. Shirley

APPROVAL: Carter K. Ford DATE: 86-12-05
Principal Investigator

OEI - WPUBM001

Purpose

The purpose of this Engineering Development Test is to obtain specific parameters pertinent to the optimization of the Waste Processing Unit (WPU) currently under development. Certain performance characteristics can best be determined by the experimental process. These include operating temperatures in various regions within the WPU, effects of insulation on internal temperatures, minimum operational inlet temperature, average cycle time as a function of inlet temperature, etc. This data will be utilized in the design optimization process for the WPU.

EQUIPMENT/MATERIALS REQUIRED

QTY	ITEM	I.D. NUMBER	
1	WPU TEST STAND	TS8611000-009	
1	EFFLUENT RETRIEVAL TRAY	(not assigned)	
1	WPU BENCH MODEL	#WPU-BM001	
1	TEMPERATURE PROBE: 200°-1000°F, 2.5" Lg.	#1	CAL Verified: NOV 14 1986
3	TEMPERATURE PROBE: 200°-1000°F, 4.5 Lg.	#2,3,4,	#2 CAL Verified: NOV 14 1986 #3 CAL Verified: NOV 14 1986 #4 CAL Verified: NOV 14 1986
A/R	Various candidate insulating materials		
A/R	Waste samples, sealed in plastic bags		
1	Thermometer, -20°F to +100°F, for recording ambient temperature		
	Documents Required		
1	Engineering Test Procedure #OEI-WPUB001 (with data sheets)		
1	Operational Procedures, WPU Test Stand (OP8611000)		

TEST STAND

CALIBRATION

(With Bench Model Installed)

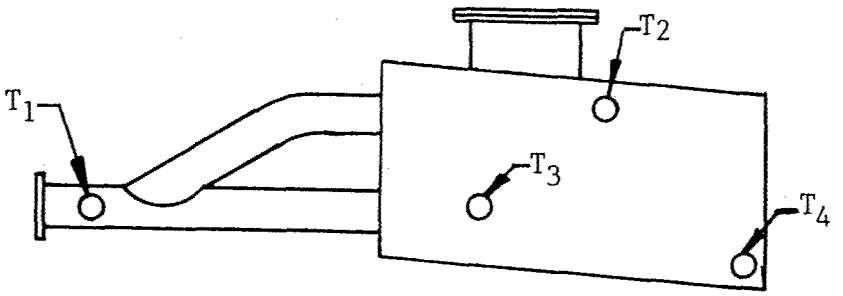
Date NOV 14 1986

TIME	RPM	T_1 F°	$T_{Ambient}$, F°
1215	1100	0	60°
1217	1100	750	60°
1220	1400	835	60°
1224	1400	900	60°
1230	1400	910	60°
1238	1400	910	60°
	Shut Down at 12:45		
1252	1000	700	61°
1255	1000	770	61°
1315	1000	800	61°
1316	1400		
1330	1400	900	61°
1332	1400	900	61°
1332	1600		
1343	1600	930	61°
1345	1600	930	61°
1345	1800		
1348	1800	1000	61°
1350	1800		61°
1350	800		61°
1354	800	730	61°
1400	800	695	61°
1407	800	680	61°

OEI - WPUBM001

TEST PROCEDURE

1.0 Following calibration of temperature probes, install temperature probes into WPU Bench Model #WPU-BM001 as shown in sketch below.



Verified LORD NOV 14 1986 Date

2.0 Install WPU-BM001 onto WPU Test Stand.

Verified LORD NOV 14 1986 Date

3.0 Activate WPU Test Stand, and adjust for an inlet temperature of 850± 25° F. record response of Temperature probe #1 through #4 until a steady state condition is reached. (Note - inlet temperature is taken from Temperature probe at WPU Test Stand Manifold)

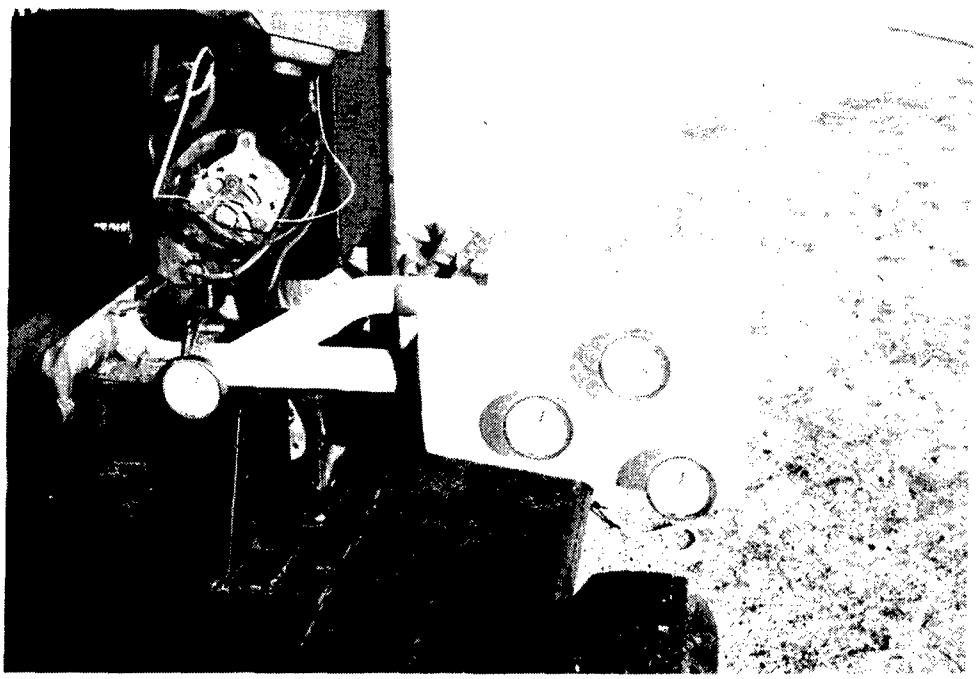
ENGINE RPM FOR 850° ± 25° F: 1200 RPM

TIME	RPM	T_1, °F	T_2, °F	T_3, °F	T_4, °F	$T_{ambient}$, °F
1430	1200	< 200	< 200	< 200	< 200	60° F
1432	1200	720	230	240	210	60°
1433	1200	770	260	290	270	60°
1434	1200	800	300	345	315	60°
1435	1200	820	330	380	350	60°
1440	1400	870	390	450	410	60°
1445	1400	890	425	480	425	60°
1451	1200	830	380	400	310	60°

Verified LORD NOV 14 1986 Date

4.0 Turn WPU Test Stand off and allow unit to return to ambient temperature.

Verified LORD NOV 14 1986 Date



5.0 Insulation Evaluation

5.1 Install candidate insulation material on WPU-BM001. Record insulation type and amount used on data sheet DS001.

5.2 Perform step 3.0 and maintain at steady state condition for 1 hour. Record data on data sheet DS001.

5.3 Turn WPU Test Stand off and allow unit to return to ambient temperature. Record time required to return to ambient temperature on data sheet DS001.

5.4 Remove candidate insulation and record condition on data sheet DS001.

5.5 Repeat steps 5.1 through 5.4 for all candidate insulation materials.

OEI - WPUBM001

DATA SHEET DS001-1

Date:_____

Candidate Insulation:

Manufacturer: Owen's Corning

Manufacturer's # : A12384702K

Type: Fiberglas (glass wool-paper vapor barrier removed)

Size: R-11 (3½")

Amount Used: 14½" x 94" total

Start up 1523

TIME	RPM	T_1, °F	T_2, °F	T_3, °F	T_4, °F	$T_{Ambient}$, °F
1523	1200	< 200	< 200	< 200	< 200	59°
1541	1200	850	535	580	610	59°
1550	1100	860	580	630	650	57°
1556	1100	880	620	640	660	56°
1557	1050	RPM LOWERED				
1559	1050	860	630	655	670	56°
1612	1050	860	640	660	670	55°
1623	1050	845	660	680	690	53°

Verified LRO NOV 14 1986 Date_____

WPU Test Stand Shutoff Time * Verified_____ Date_____

Time to Return to Ambient Temp: Time ** Verified_____ Date_____

** N/A - See DS001-2

Insulation Condition:

Comments: 1612: Steam (?) emanating around joints in insulation, plus noticiable discoloration of insulation around joints - also strong "burned paint" smell. (Picture #7 (approx.)

*Not shut off - went directly to DS001-2

6.0 Waste Processing Tests

6.1 Install selected insulation material on WPUBM001.

Verified LORD DEC 03 1986 ~~NOV 14 1986~~ Date

6.2 Attach effluent retrieval tray to the outlet of WPUBM001.

Verified LORD DEC 03 1986 Date

6.3 Activate WPU Test Stand, and adjust to attain an inlet temperature of 850± 25°F. Allow system to reach steady state condition and record temperatures on data sheet DS002.

6.4 Weigh a waste sample and record on data sheet DS002.

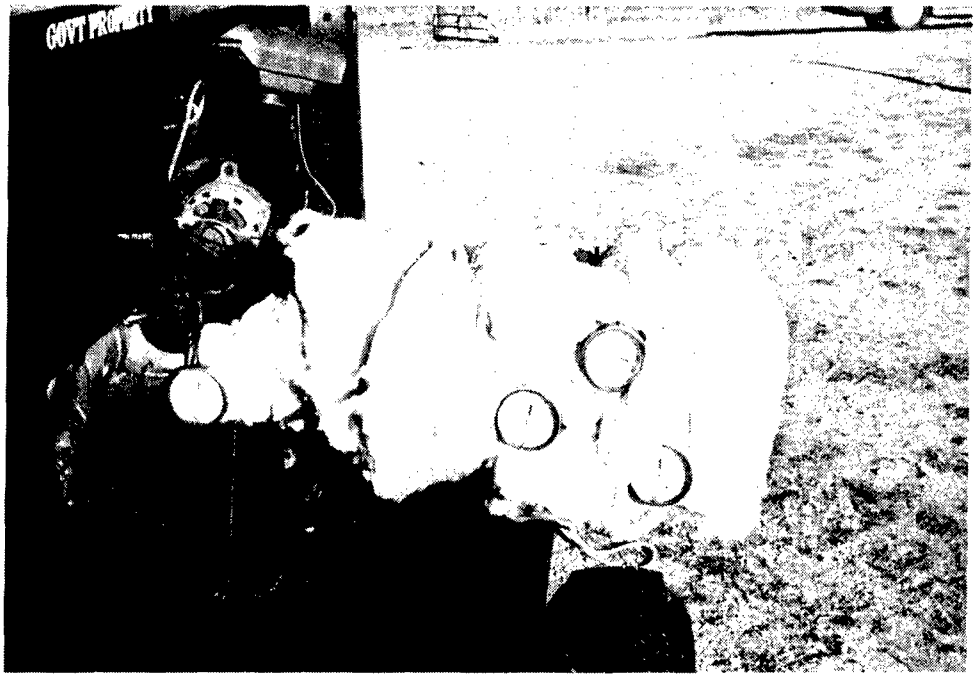
6.5 Place waste sample into WPUBM001 and record response of system on data sheet DS002. Continue operating unit for 15 minutes. Use video system to record characteristics of effluents.

6.6 Turn WPU Test Stand Off and allow unit to return to ambient temperature. Remove side plate of WPUBM001 and inspect condition of unit and contents, if any.

6.7 Weigh contents of effluent retrieval tray and record on data sheet DS002.

6.8 Repeat steps 6.2 through 6.7 for various inlet temperatures (minimum of 4).

6.9 Record results, observations, conclusions, etc. on data sheet DS003.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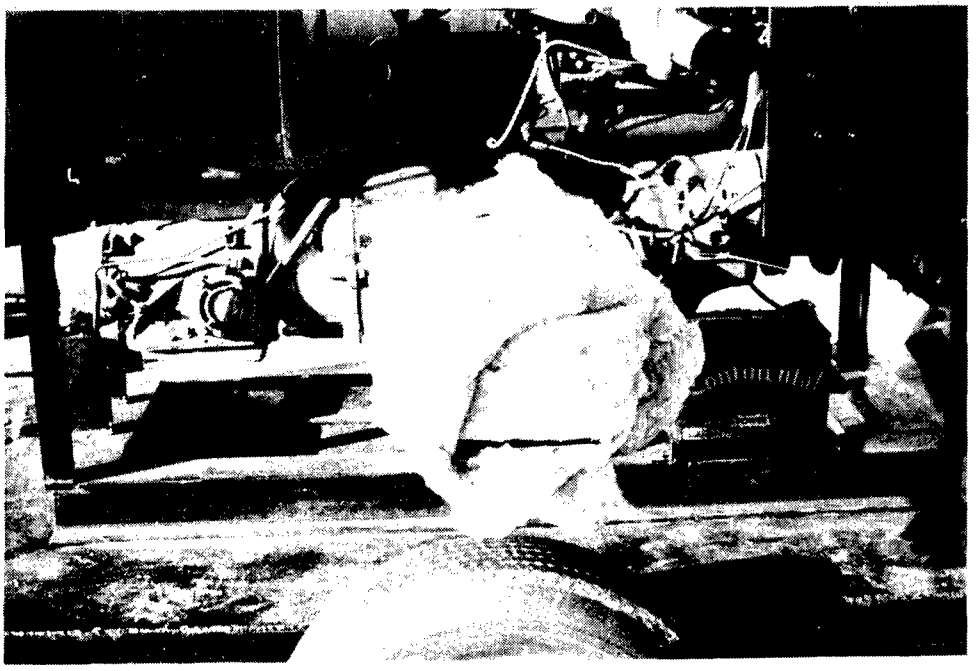


OEI - WPUBM001

DATA SHEET DS001-2

Date: NOV 14 1986

Candidate Insulation:

Manufacturer: Owen's Corning

Manufacturer's # : A12384702K

Type: Fiberglas (glass wool - paper vapor barrier removed)

Size: R11 ($3\frac{1}{2}$" nominal)

Amount Used: $14\frac{1}{2}$" x 94" total + waste hatch cover $14\frac{1}{2}$ x $10\frac{1}{2}$ (picture #8)

Note: Waste hatch cover added while temp. at final conditions of DS001-1

TIME	RPM	T_1, °F	T_2, °F	T_3, °F	T_4, °F	$T_{Ambient}$, °F
1623	1050	845	660	680	690	53°
1627	1050	840	670	690	700	52°
(RPM Adjusted to 1110)						
1635	1100	850	690	710	720	50°
1644	1100	860	720	730	740	48°
*1845	0	< 200	330	320	250	34°

Verified LORD Date NOV 14 1986

WPU Test Stand Shutoff Time 1644 Verified LORD Date NOV 14 1986

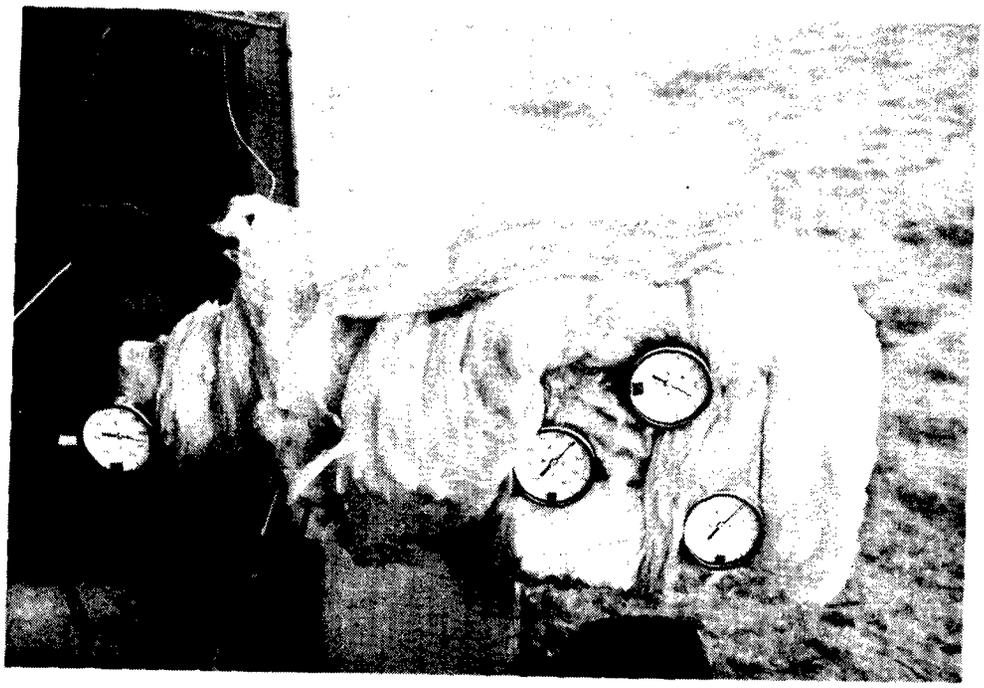
Time to Return to Ambient Temp: Time See Below Verified LORD Date NOV 14 1986

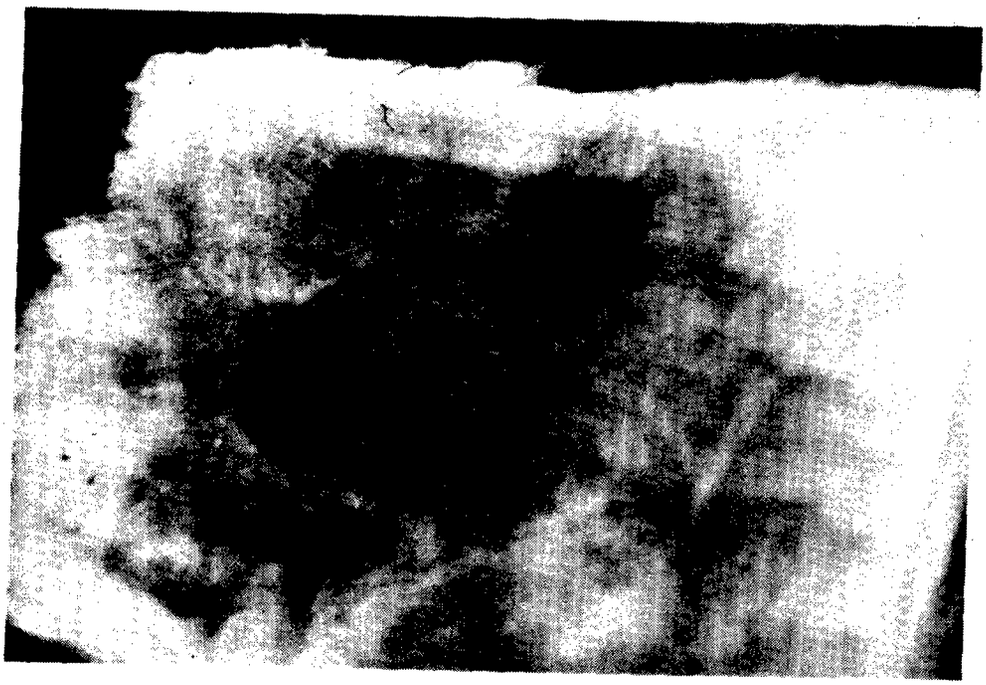
> 2 hrs - T_2 & T_4 still not returned to ambient - Test Concluded

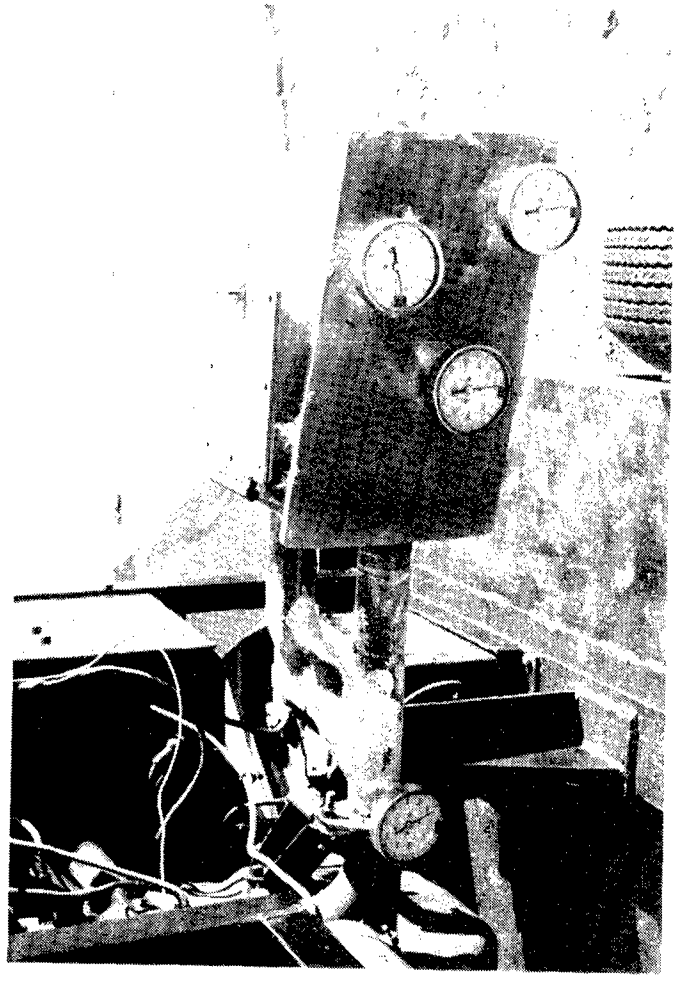
Insulation Condition: Discolored to seams

Discoloration appears to be from degradation of paint used on Bench Model.

Comments: 1623-noticeable "smoke" noticed when waste hatch cover insulation added.







OEI - WPUBM001

DATA SHEET DS001-3

Date: NOV 19 1986

Candidate Insulation:

Manufacturer: Johns Manville

Manufacturer's # : 5346474

Type: Cera Blanket

Size: 6 lb., 1" thick

Amount Used: 24" x 48" total

TIME	RPM	T_1, °F	T_2, °F	T_3, °F	T_4, °F	$T_{Ambient}$, °F
1200	1050	< 200	< 200	< 200	< 200	69°
1215	1050	830	365	440	450	67°
1230	1050	850	560	600	610	66°
1245	1050	850	655	690	685	63°
1300	1050	850	710	735	730	60°
1315	1050	315	620	610	430	56°
1340	1050	< 200	500	480	330	54°

Verified LORO Date NOV 19 1986

WPU Test Stand Shutoff Time 1300 Verified LORO Date NOV 19 1986

Time to Return to Ambient Temp: Time > 1 hr. Verified LORO Date NOV 19 1986

Insulation Condition: No degradation

Comments: Priorto installation of Cera Blanket, white paint and primer removed (as best as possible) and replaced with high temp. black paint.
10 - 25 mph wind blowing across unit.

OEI - WPUBM001

DATA SHEET DS001-4

Date: NOV 25 1986

Candidate Insulation:

Manufacturer: Johns Manville

Manufacturer's # : 5346474

Type: Cera Blanket

Size: 6 lb., 1" thick

Amount Used: 24" x 96" total (2 layers)

TIME	RPM	T_1, °F	T_2, °F	T_3, °F	T_4, °F	$T_{Ambient}$, °F
0915	950	< 200	< 200	< 200	< 200	35°
0930	950	850	570	550	400	40°
0945	950	875	605	585	475	45°
1000	950	860	630	620	530	45°
1015	950	860	655	655	630	46°
1045	950	350	580	600	530	41°

Verified /ORP NOV 25 1986 Date

WPU Test Stand Shutoff Time 1015 Verified /ORP Date NOV 25 1986

Time to Return to Ambient Temp: Time > 2 hrs Verified /ORP Date NOV 25 1986

Insulation Condition: No degradation

Comments: Prior to test, insulation soaked at approximately 30° F. for several hours.

OEI - WPUBM001

DATA SHEET DS001-5

Date: DEC 0 3 1986

Candidate Insulation:

Manufacturer: Johns Manville

Manufacturer's # : 5346474

Type: Cera Blanket

Size: 6 lb., 1" thick

Amount Used: 24" x 48" less 8"x8" - end of WPU not insulted - Effluent Retrieval Tray Installed

TIME	RPM	T_1, °F	T_2, °F	T_3, °F	T_4, °F	$T_{Ambient}$, °F
1030	950	< 200	< 200	< 200	< 200	20°
1045	950	870	600	630	600	24°
1100	950	840	630	615	520	25°
1115	950	850	650	630	535	26°
1130	950	840	660	640	545	26°

Verified [illegible] Date DEC 0 3 198

WPU Test Stand Shutoff Time 1130 Verified [illegible] Date DEC 0 3 1986

Time to Return to Ambient Temp: Time > 2 hrs Verified [illegible] Date DEC 0 3 1986

Insulation Condition:

Comments:

OEI - WPUBM001

Data Sheet DS002-1

Date: DEC 03 1986

6.3 Preliminary Status

TIME	INLET T_1 °F	T_2 °F	T_3 °F	T_4 °F	$T_{ambient}$, °F
1315	865	645	675	660	30°

Verified LORD Date DEC 03 1986

6.4 Waste Sample:

Sample # 1

Description: 12 oz. water in 8"x5" Heat Sealable Bag.

weight: Solid:_____ Liquid:_____ Bag:_____ } 12 oz.

Verified LORD Date DEC 03 1986

6.5 Response to Waste Insertion (use video system also)

TIME	T_1, °F	T_2, °F	T_3, °F	T_4, °F	$T_{ambient}$, °F
1320	870	680	640	580	30°
1325	865	670	650	610	28°
1330	865	675	670	625	28°
1335	865	685	680	670	28°
1340	865	700	715	700	28°
1345	865	720	740	725	28°
1350	865	740	755	750	28°
1355	860	750	765	750	28°

Verified LORD Date DEC 03 1986

Description of Effluents : Approximately 1 TBSP ~~Spoon~~ (sooty) liquid appeared immediately after insertion of sample.

6.6 Description of WPUBM001 interior and contents: Interior unchanged - small spot (2" x 3") of sooty plastic residue on bottom.

Weight of contents: approx. 0

OEI - WPUBM001

Data Sheet DS002 (cont.)

Date: DEC 03 1986

6.7 Effluent Description:

weight: -0-

Comments: After the first 5 minutes there was a small amount of liquid in ruptured bag. (approx. 1 TB. Spoon)

10 minutes after insertion of bag: still small amount of liquid and plastic

15 minutes after insertion of bag: No liquid - small amount of plastic

20 minutes after insertion of bag: No liquid - small amount of plastic

25 minutes after insertion of bag: No liquid - small amount of plastic

30 minutes - same conditions as previous.

35 minutes - Plastic burning nicely - small amount left.

40 minutes after insertion of bag: very small amount plastic residue left.

41 minutes smoky black residue left at bottom of chamber.

OEI - WPUBM001

Data Sheet DS002-2

Date: DEC 03 1986

6.3 Preliminary Status

TIME	INLET T_1 °F	T_2 °F	T_3 °F	T_4 °F	$T_{ambient}$, °F
1415	840	665	700	680	28°

Verified LORD Date DEC 03 1986

6.4 Waste Sample:

Sample # 2

Description: Cooked Oatmeal + 6 sq. 2 ply toilet tissue in 8"x5" Heat Seatable Bag.

weight: Solid:_____ Liquid:_____ 6 oz. Bag:_____ Total wt.

Verified LORD Date DEC 03 1986

6.5 Response to Waste Insertion (use video system also)

TIME	T_1, °F	T_2 °F	T_3 °F	T_4 °F	$T_{ambient}$, °F
1415	870	700	425	650	28°
1420	865	700	390	640	28°
1425	850	720	510	660	28°
1435	850	740	640	710	28°
1445	850	755	760	740	26°
1455	865	780	795	770	24°
1505	865	785	805	795	24°
1515	865	790	805	800	24°

Verified LORD Date DEC 03 1986

Description of Effluents: Approximately 4 TB. Spoon Black Ash in Effluent Retrieval Tray.

6.6 Description of WPUBM001 interior and contents:
Small amount of Black Ash in Bottom

Weight of contents: .3097 oz

OEI - WPUBM001

Data Sheet DS002 (cont.)

Date: DEC 03 1986

6.7 Effluent Description:

weight: .3097 oz

Comments: 5 Minutes after insertion of bag: Outside edge charred

10 minutes after insertion of bag: Outside is completely charred.

20 minutes after insertion of bag: Package is visibly smaller and charred.

30 minutes after insertion of of bag: Bag and contents about ½ the size when put in. Smoke visible from exhaust, no particule being discharged in catch pan.

40 minutes after insertion of bag: Small amount of burned particules in pan. 3 TB. Spoons.

50 minutes after insertion of bag: very small amount left, about 3 or 4 TB. Spoons. Debris in catch pan, no smoke visible.

60 minutes after insertion of bag: all gone--3 to 4 TB spoons in catch pan.

OEI - WPUBM001

Data Sheet DS002-3

Date: DEC 04 1986

6.3 Preliminary Status

TIME	INLET T_1 °F	T_2 °F	T_3 °F	T_4 °F	$T_{ambient}$, °F
1030	850	610	610	540	25°

Verified LORD Date DEC 04 198

6.4 Waste Sample:

Sample # 3

Description: 7.5 oz. Canned Dog Food
6 sq. 2 ply toilet tissue
8"x5" heat sealable Bag (plastic)
dog food formed into 7"x3"x1" block

weight: Solid: 7.6 oz.
Liquid: 0
Bag: 43 gr.

Verified LORD Date DEC 04 198

6.5 Response to Waste Insertion (use video system also)

TIME	T_1, °F	T_2 °F	T_3 °F	T_4 °F	$T_{ambient}$, °F
1030	850	610	610	540	25°
1035	860	635	560	535	26°
1040	865	650	580	570	27°
1045	865	670	620	580	27°
1055	865	695	650	600	28°
1105	870	705	675	610	30°
1115	850	700	550	595	32°
1125	865	710	625	625	32°
1135	865	730	740	660	32°
1145	860	735	740	660	32°
1155	865	730	730	640	32°
1205	865	740	740	665	31°
1235	850	750	740	665	31°

Verified LORD Date DEC 04 1986

Description of Effluents :

6.6 Description of WPUBM001 interior and contents:

Weight of contents: .5463 oz

Data Sheet DS002 (cont.)

Date: DEC 04 1986

6.7 Effluent Description:

weight: .546302

Comments: 5 minutes after insertion of bag: no visible smoke, bag ruptured and edges charred, no contents in catch pan. Smell it charring.

10 minutes after insertion of bag: No visible smoke a little more charred-- no contents in catch pan. Smell it charring.

15 minutes after insertion of bag: No visible smoke can smell it burning. charred nicely.

25 minutes after insertion of bag: Light smoke visible - still smell it burning nicely - about the original size.

35 minutes after insertion of bag: Well charred, more smoke, very small amount of ash in catch pan.

45 minutes after insertion of bag: About ½ gone, smoke visible, smell, very small amount of ash in catch pan.

55 minutes after insertion of bag: Fair amount of smoke - still smell it.

65 minutes after insertion of bag: Fair amount of smoke - still smell it, ½ gone

75 minutes after insertion of bag: smoke fair amount, smells real nice - about ½ gone, picking up more ash. 1 TB Spoon.

85 minutes after insertion of bag: Very little smoke still smells - ½ to two thirds gone. 2 charred pieces left.

95 minutes after insertion of bag: No noticeable smoke - smell not so strong. About 1 TB. Spoon of ash.

125 minutes after insertion of bag: No smell except engine exhaust. No smoke No noticeable change in size of charred remaines.

OEI - WPUBM001

Data Sheet DS002-4

Date: DEC 04 1986

6.3 Preliminary Status

TIME	INLET T_1 °F	T_2 °F	T_3 °F	T_4 °F	$T_{ambient}$, °F
1330	850	650	670	650	30°

Verified LORD Date DEC 04 1986

6.4 Waste Sample:

Sample # 4

Description: 7.5 oz. Canned Dog food
6 sq. 2 ply. toilet tissue
6 oz. water
kneaded into slurry
in 8"x6" heat sealable plastic bag.

weight: Solid: 7.6 oz.
Liquid: 6 oz.
Bag: 50 gr.

Verified LORD Date DEC 04 1986

6.5 Response to Waste Insertion (use video system also)

TIME	T_1, °F	T_2, °F	T_3, °F	T_4, °F	$T_{ambient}$, °F
1330	850	650	670	650	30°
1335	870	700	540	640	28°
1345	870	730	690	690	28°
1355	860	740	715	695	30°
1405	860	760	760	725	30°
1415	860	765	765	735	31°
1425	860	770	780	750	31°
1435	860	780	795	765	31°
1445	860	790	810	775	31°
1450	855	795	815	775	30°
1500	855	795	815	780	30°
1505	855	800	815	780	30°

Verified LORD Date DEC 04 1986

Description of Effluents :

6.6 Description of WPUBM001 interior and contents:

Weight of contents: 3657 oz

OEI - WPUBM001

Data Sheet DS002 (cont.)

Date: DEC 04 1986

6.7 Effluent Description:

weight: .365702

Comments: 30 seconds after insertion of bag: Noticeable smell.

5 minutes after insertion of bag: No visible smoke - strong smell - bag ruptured liquid boiling some charring.

15 mintes after insertion of bag: Fair amount of smoke burning smell - no ash yet. Outsides and surfaces charred well. No liquid boiling.

25 minutes after insertion of bag: Strong charred or burning smell - fair amount of smoke. No liquid visible - charred - no particules in catch pan.

35 minutes after insertion of bag: Goodly amount of smoke, very, very small amount of ash in catcher bag and contents heavily charred.

45 minutes after insertion of bag: Conditions same as last entry.

55 minutes after insertion of bag: Same amount of smoke, strong smell (charring) very little amount of particules yet. $\frac{1}{4}$ teaspoon, heavily charred. About $\frac{1}{2}$ to 2/3 gone.

65 minutes after insertion of bag: Fair amount of smoke, strong charring smell. about 3/4 gone. Still very, very little ash in catch pans.

75 minutes after insertion of bag: Very little smoke, charring smell not strong, still very little ash in catch pans. Remains in chamber still burning, not much size difference.

85 minutes after insertion of bag: Same as above:

95 minutes after insertion of bag: No smell except engine exhaust, no smoke.

100 minutes after insertion of bag: No smell, No smoke, end of test. 2 small incinerated pieces about 3/8" thick 2" long left in chamber. $\frac{1}{2}$ teaspoon in catch pans.

OEI - WPUBM001

Data Sheet DS002-5

Date: DEC 05 1986

6.3 Preliminary Status

TIME	INLET T_1 °F	T_2 °F	T_3 °F	T_4 °F	$T_{ambient}$, °F
920	860	610	600	530	34°

Verified LOR Date DEC 05 1986

6.4 Waste Sample:

Sample # 5

Description: Human Fecal Matter (solid)
6 oz. Water
6 sq. Toilet Tissue
1 paper towel
in heat sealable plastic bag

weight: Solid: 8oz.
Liquid: 6 oz.
Bag: 50 gr.
14 oz. sealed wt.

Verified LOR Date DEC 05 1986

6.5 Response to Waste Insertion (use video system also)

TIME	T_1, °F	T_2, °F	T_3, °F	T_4, °F	$T_{ambient}$, °F
920	860	610	600	530	34°
930	860	600	435	500	36°
940	865	630	520	540	37°
950	870	640	560	560	37°
1000	850	660	600	580	37°
1010	860	670	620	590	40°
1015	865	680	630	595	42°
1020	865	690	640	600	42°
1025	870	690	650	620	40°
1030	855	695	655	600	40°
1035	860	695	660	620	40°
1040	865	700	660	625	40°
1045	865	700	670	630	40°
1050	870	700	670	630	42°
1055	870	705	680	630	42°
1100	850	700	680	620	40°

Description of Effluents :

Verified LOR Date DEC 05 1986

6.6 Description of WPUBM001 interior and contents:

Weight of contents: 3337 oz

OEI - WPUBM001

Data Sheet DS002 (cont.)

Date: DEC 05 1986

6.7 Effluent Description:

weight: .3337 oz

Comments: 10 seconds after insertion of bag: Strong Smell

10 minutes after insertion of bag: Very strong smell, no smoke yet, lightly charred around edges, bag ruptured.

20 minutes after insertion of bag: Smell not as stong, no visible smoke yet, heavy charring, no liquid visible, small amount of ash.

30 minutes after insertion of bag: smell not as strong, no visible smoke, small amount of ash, heavy charring.

40 minutes after insertion of bag: smell is about the same, still no visible smoke, same amount of ash,size of contents smaller, heavily charred.

50 minutes after insertion of bag: Smell decreasing, visible smoke, heavy charring still.

55 minutes after insertion of bag: Smell decreasing, still fair amount of smoke, no noticeable change in contents of burner from last check, still very small, amount of ash in catch pans.

60 minutes after insertion of bag: Fair amount of smoke, smell decreasing, no noticeable change in contents size, heavily charred.

65 minutes after insertion of Bag: Same amount of smoke, no change in ash in catch pans, smell not bad, contents looks a little smaller, charred heavily.

70 minutes after insertion of bag: smokes decreasing, smell the same.

75 minutes after insertion of bag: No visible smoke, smell decreasing, smells of burnt or charred whatever, same amount of ash in catch pans. No visible changes in contents size.

80 minutes after insertion of bag: No visible changes from last time checked. Small amount of ash, no bad smell that I can tell. No smoke visible. Contents looks thinner and smaller.

85 minutes after insertion of bag:

Comments: (cont)

90 minutes after insertion of bag: Charring smell only, no smoke visible, same amount of ash, contents breaking up a little.

95 minutes after insertion of bag: Same as last check.

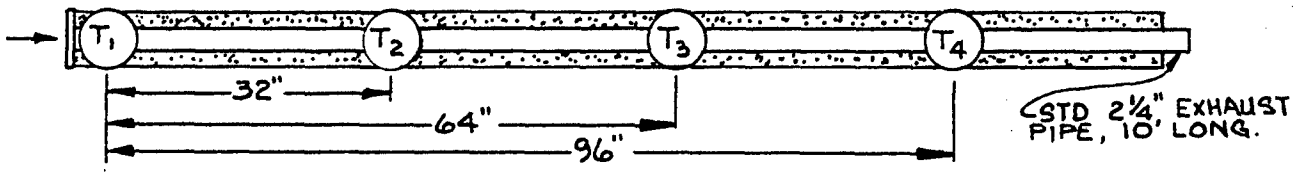
100 minutes after insertion of bag: Done, test completed.
No smell except engine exhaust.
small amount of ash in catch pans.
1 clinker in burn chamber.

OEI - WPUBM001

Data Sheet DS003

Date: DEC 30 1986

Temperature Gradient Test



Insulation: "Cerablanket" #5346474, 6 lb., 1" thk, with aluminum foil outer layer

Procedure: Install tube on Test Stand and start Test Stand. Adjust Test Stand to provide 900° F. at T_1. Record temperatures at T_1 through T_4 at 10 minute intervals until steady state conditions are attained. Shut down Test Stand.

TIME	$T_{ambient}$, °F	T_1, °F	T_2, °F	T_3, °F	T_4, °F
9:48	27	<200	<200	<200	<200
9:55	29	915	870	800	760
9:58	30	910	880	820	785
10:08	30	905	900	860	830
10:16	30	910	900	870	845
10:24	30	925	910	880	855
10:32	31	910	910	875	845
10:40	32	910	900	870	845
10:48	32	915	900	870	845
10:58	36	910	900	870	845
	DROPPED INLET TEMPERATURE TO 850° AT			11:00 HOURS	
11:00	36	900	900	870	845
11:05	37	850	865	830	800
11:10	37	850	845	820	790
11:15	37	855	845	815	785
11:20	39	850	840	810	780
11:25	39	850	840	810	780
11:30	38	855	840	810	780

Verified LORD Date DEC 30 1986

APPENDIX B

WPU DEVELOPMENT UNIT TEST

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ENGINEERING DEVELOPMENT TEST:

WASTE PROCESSING UNIT DEVELOPMENT TEST PROCEDURE

#OEI - WPUD001

TEST DATE: Aug 17-19, 1987

TEST CONDUCTOR: _____

APPROVAL: Carter K. Ford DATE: AUG 19 1987
Principal Investigator

OEI - WPUD001

Purpose

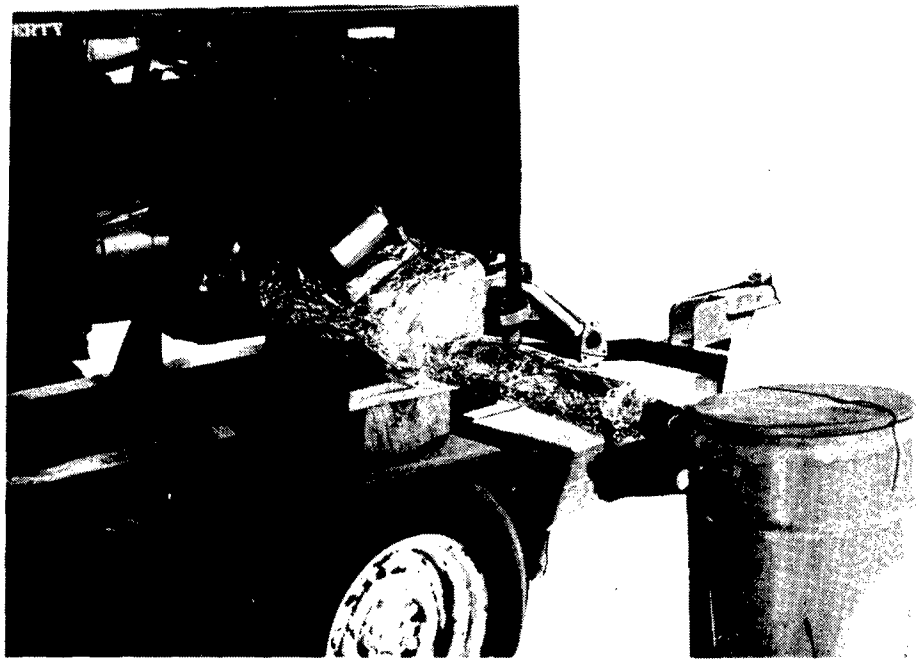
The purpose of this Engineering Development Test is to determine specific parameters pertinent to the performance of the Waste Processing Unit (WPU) currently under development. Certain performance characteristics can best be determined by the experimental process. These include operating temperatures within the WPU, effects of insulation on internal temperatures, seal performance, minimum operational inlet temperature, average cycle time as a function of inlet temperature, etc.

EQUIPMENT/MATERIALS REQUIRED

QTY	ITEM	I.D. NUMBER	
1	WPU TEST STAND		
1	EFFLUENT RETRIEVAL UNIT	(not assigned)	
1	WPU DEVELOPMENT UNIT (with adaptor inlet and outlet pipes)	#WPU-BM001 8611TAC0100-009	
1	TEMPERATURE PROBE: 200°-1000°F (2.5" Lg.)	#1	CAL Verified: LORD AUG 17 1987
1	TEMPERATURE PROBE: 200°-1000°F (4.5" Lg.)	#2	#2 CAL Verified: LORD AUG 17 1987
A/R	Waste samples, sealed in plastic bags		
1	Thermometer, -20°F to +100°F, for recording ambient temperature		

Documents Required

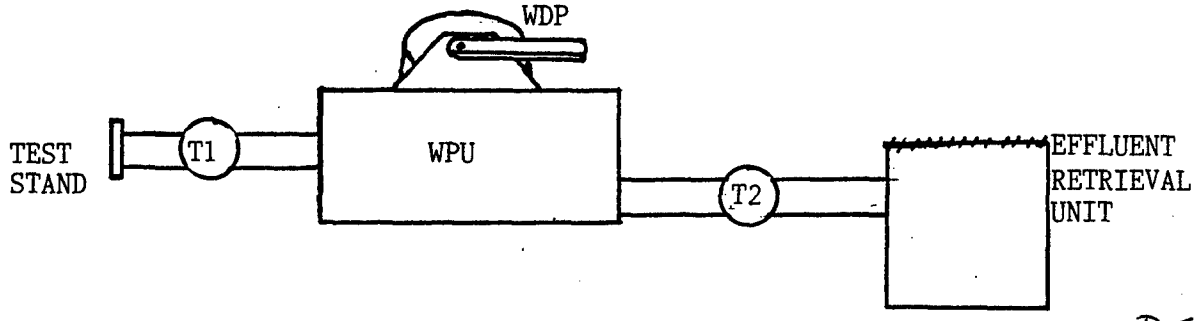
1	Engineering Test Procedure #OEI-WPUD001 (with data sheets)
1	Operational Procedures, WPU Test Stand (OP8611000)



OEI - WPUD001

TEST PROCEDURE

1.0 Following calibration of temperature probes, install temperature probes into WPU Development Unit 8611TAC0100-009 as shown in sketch below.



Verified LORD Date AUG 17 1987

2.0 Install Development Unit onto WPU Test Stand using sections of pipe provided.

Verified LORD Date AUG 17 1987

3.0 With WDP in the "up" position, activate WPU Test Stand and adjust for an inlet response of Temperature probe #1 and #2 until a steady state condition is reached. (Note - inlet temperature is taken from T_1)

TIME	RPM	T_1, °F	T_2, °F			$T_{ambient}$, °F
1405	0	<200	<200			93
1406	1100	350	<200			93
1407	1100	575	340			93
1408	1100	680	475			93
1410	1200	710	510			93
1415	1100	720	520			96
1416	1100	730	530			96
1417	SHUT DOWN -MECHANICAL PROBLEMS WITH TEST STAND ENGINE- SEE NEXT SHEET					

Verified LORD Date AUG 17 1987

4.0 Turn WPU Test Stand off and allow unit to return to ambient temperature.

Verified LORD Date AUG 17 1987

OEI - WPUD001

TEST PROCEDURE

1.0 Following calibration of temperature probes, install temperature probes into WPU Development Unit 8611TAC0100-009 as shown in sketch below.

SEE SKETCH, PREVIOUS PAGE

Verified LORD Date AUG 17 1987

2.0 Install Development Unit onto WPU Test Stand using sections of pipe provided.

Verified LORD Date AUG 17 1987

3.0 With WDP in the "up" position, activate WPU Test Stand and adjust for an inlet response of Temperature probe #1 and #2 until a steady state condition is reached. (Note - inlet temperature is taken from T_1)

TIME	RPM	T_1, °F	T_2, °F			$T_{ambient}$, °F
1437	0	270	270			93
1438	1100	270	270			93
1440	1100	575	440			93
1442	1100	650	475			93
1444	1150	710	560			95
1446	1100	740	600			95
1448	1150	730	620			95
1450	1250	760	640			95
1455	1300	810	685			95
1457	1250	840	720			95
1459	1250	840	725			95
1501	1250	850	740			95

(more data & comments on back)

Verified LORD Date AUG 17 1987

4.0 Turn WPU Test Stand off and allow unit to return to ambient temperature.

Verified LORD Date AUG 17 1987

TIME	RPM	T_1, °F	T_2, °F		$T_{ambient}$, °F
1504	1250	850	755		95
1509	1250	850	770		95
1514	1250	855	780		95
1519	1250	850	783		96
1524	1250	850	790		96
1529	1225	850	790		96
1534	1250	850	790		96
1539	1250	850	795		98
1545	1250	850	795		98
1546	PULLED T_2 GAUGE & PLACED IN WDP. READING : 210 °F.				

COMMENT: NO NOTICE OF ANY LEAKS AROUND SEALS AT DRUM (WDP)

5.0 Waste Processing Tests

5.1 Attach effluent retrieval unit to the outlet of WPU.

Verified LORD Date AUG 1 8 1987

5.2 Weigh a waste sample and record on data sheet DS002.

5.3 Place a waste sample into WPU, and return WDP to the "UP" position. Record response of system on data sheet DS002. Continue operating unit for 15 minutes. Use Video system to record characteristics of effluents.

5.4 With the WDP in the "UP" position, activate the WPU Test Stand, and adjust to attain an inlet temperature of 850 ± 25°F. Allow system to reach steady state condition and record temperatures on data sheet DS002.

5.5 Turn WPU Test Stand Off and allow unit to return to ambient temperature. Remove side plate of WPU and inspect condition of unit and contents, if any.

5.6 Weigh contents of effluent retrieval unit and record on data sheet DS002.

5.7 Repeat steps 5.1 through 5.6 for various inlet temperatures (minimum of 4).

5.8 Record results, observations, conclutions, etc. on data sheet DS003.

5.9 Repeat steps 5.1, 5.2, and 5.4 thru 5.7 with WPU at steady state operating temperature of T_1 = 850° ± 25° F.

SAMPLE # 1

OEI - WPUD001

Data Sheet DS002

Date: AUG 18 1987

5.4 Preliminary Status

TIME	INLET T_1 °F	T_1, °F	T_2, °F		$T_{ambient}$, °F
0905	<200	<200	<200		62

Verified LORD Date AUG 18 1987

5.2 Waste Sample:

Sample # 1 TOTAL WEIGHT: 16 oz

Description: CANNED CHUNK STYLE DOG FOOD
5 SQUARES 2 PLY TOILET TISSUE
WATER

weight: Solid: 7 oz
Liquid: 8½ oz
Bag: ½ oz

TEST RUN #1, SET INLET TEMP @ 850°±25 °F

Verified LORD Date AUG 18 1987

5.3 Response to Waste Insertion (use video system also)

TIME	T_1, °F	T_2, °F			$T_{ambient}$, °F
0912	620	330			62
0914	710	420			62
0918	810	535			64
0922	875	650			70
0925	850	630			70
0928	850	655			70
0931	850	675			70
0935	850	725			72
0940	855	735			72
0945	850	745			72
0950	850	760			74
1000	850	780			76
1010	850	790			76
1015	850	795			78

Verified LORD Date AUG 18 1987

Description of Effluents : White fly ash varying in size up to ¼" long.
Black charred ash a little larger in size

5.5 Description of WPUBM001 interior and contents: Small amount of white ash. One piece of completely charred black cinder - very light in weight- crumbles when touched. Very light stain on bottom of WPU. Otherwise, chamber is quite clean. Seals appear unchanged.

Weight of contents: <1 oz

SAMPLE #1

OEI - WPUD001

Data Sheet DS002 (cont.)

Date: AUG 1 8 1987

5.6 Effluent Description: SEE BELOW & previous page

weight: <1 OZ

TIME:
0914 Slight smell- no smoke visible- no liquid or steam visible
0918 Considerable odor- smoke visible
0922 considerable light blue smoke- charred smell
0925 Considerable light blue smoke- charred smell
0928 Still smoking- charred smell
0931 Less smoke- charred smell- no visible effluents in retrieval unit yet
0935 More smoke- strong charred smell
0940 Same as above
0945 Lots of light blue smoke-strong charred smell
0950 Same as above
1000 Less smoke- still strong charred smell
smoke dissipates within 15 - 20 feet from unit
1010 Much less light blue smoke- minimal charred smell
1015 No smoke visible- very little charred smell

SAMPLE #2

OEI - WPUD001

Data Sheet DS002

Date: AUG 18 1987

5.4 Preliminary Status

TIME	INLET T_1 °F		T_2 °F		$T_{ambient}$, °F
1400	200		<200		93

Verified LORD Date AUG 18 1987

5.2 Waste Sample:

Sample #2 TOTAL WEIGHT 16 oz

Description: CANNED CHUNK STYLE DOG FOOD
5 SQUARES 2 PLY TOILET TISSUE
WATER

weight: Solid: 7½ oz
Liquid: 8 oz
Bag: ½ oz

TEST RUN # 2 INLET TEMPERATURE SET AT 700±25°F

Verified LORD Date AUG 18 1987

5.3 Response to Waste Insertion (use video system also)

TIME	T_1, °F	T_2 °F			$T_{ambient}$, °F
1401	300	<200			83
1405	580	340			83
1406	690	450			83
1410	700	480			83
1415	715	495			84
1420	710	500			84
1430	710	555			86
1445	710	590			88
1451	710	615			88
1500	710	625			88
1515	705	635			88
1530	700	640			88
1545	690	640			87
1548 SHUTDOWN- TEST COMPLETED					

Verified LORD Date AUG 18 1987

NOTE: ENGINE EXHAUST AFFECTING AMBIENT TEMPERATURE READING LORD AUG 18 1987

Description of Effluents : SAME AS TEST SAMPLE #1

5.5 Description of WPUBM001 interior and contents:

LOOKS THE SAME AS AFTER TEST SAMPLE #1

Weight of contents: <1 Oz

SAMPLE #2

OEI - WPUD001

Data Sheet DS002 (cont.)

Date: AUG 1 8 1987

5.6 Effluent Description: SEE BELOW AND PREVIOUS PAGE

weight: 1 oz

1405 NO SMELL, NO SMOKE, NORMAL EXHAUST ODOR
1406 SLIGHT SMELL, NO VISIBLE SMOKE
1410 NO SMOKE VISIBLE, PLEASANT "COOKING" SMELL
1415 NO SMOKE VISIBLE, PLEASANT "COOKING" SMELL
CAN STILL HOLD HAND ON INSIDE OF DRUM FOR 10-15 SECONDS
1420 NO SMOKE VISIBLE, PLEASANT "COOKING" SMELL
1430 NO CHANGE
1445 SOME CHARRING SMELL - NO VISIBLE SMOKE
1451 INCREASED CHARRING SMELL - A LITTLE VISIBLE LIGHT BLUE SMOKE
1454 INCREASING SMELL, INCREASING SMOKE
1500 STEADY LIGHT BLUE SMOKE, CHARRED SMELL
1504 SMOKE STILL INCREASING, DISSIPATES IN 20 FEET. Charred smell
1515 NO CHANGE
1530 NO CHANGE
1544 LESS SMOKE, LESS CHARRED SMELL
1545 NO SMOKE VISIBLE, SLIGHT CHARRED SMELL
1548 END OF TEST

SAMPLE #3

OEI - WPUD001

Data Sheet DS002

Date: AUG 19 1987

5.4 Preliminary Status

TIME	INLET T_1 °F		T_2 °F		$T_{ambient}$, °F
0812	200		200		74

Verified ORD Date AUG 19 1987

5.2 Waste Sample: #3 TOTAL WEIGHT: 16 oz

Sample #3

Description: CANNED CHUNK STYLE DOG FOOD
5 SQUARES 2 PLY TOILET TISSUE
WATER

weight: Solid: 7½ oz
Liquid: 8 oz
Bag: ½ oz

TEST #3 SET INLET TEMP @ 850°±25°F
STARTING FROM A COLD STARTUP

Verified ORD Date AUG 19 1987

5.3 Response to Waste Insertion (use video system also)

TIME	T_1, °F	T_2 °F			$T_{ambient}$, °F
0813	300	200			74
0815	560	300			74
0820	810	520			74
0825	810	600			74
0835	850	680			75
0840	850	710			75
0845	855	740			75
0850	855	755			75
0855	855	760			75
0900	855	780			75
0905	855	790			75
0910	855	790			75
0915	850	800			75
0915	TEST #3 COMPLETED				

Verified ORD Date AUG 19 1987

Description of Effluents : NOT AVAILABLE-NOT REMOVED BEFORE SAMPLE #4 INSERTED

5.5 Description of WPUBM001 interior and contents: NOT AVAILABLE -

Weight of contents: NOT AVAILABLE

SAMPLE #3

OEI - WPUD001

Data Sheet DS002 (cont.)

Date: AUG 19 1987

5.6 Effluent Description: NOT AVAILABLE- NOT REMOVED BEFORE SAMPLE #4 DEPOSITED

weight: NOT AVAILABLE°

TIME	
0813	START UP
0815	NO SMELL, NO SMOKE
0818	no smell, no smoke
0819	A LITTLE SMELL, NO SMOKE
0820	"COOKING" SMELL, VERY LIGHT SMOKE
0821	WDP DRUM STILL COOL
0825	STRONG "COOKING" SMELL, A LITTLE MORE LIGHT BLUE SMOKE
0828	MORE SMOKE, CHARRING SMELL STARTING, SMOKE DISSIPATES QUICKLY
0832	CHARRED SMELL, LIGHT BLUE SMOKE (normal amount)
0840	NO CHANGE
0845	NO CHANGE
0855	NO CHANGE
0857	SEE PICTURE OF SMOKE
0905	STRONG CHARRED SMELL, NORMAL AMOUNT OF LIGHT BLUE SMOKE
0910	SMOKE SUBSIDING, SMELL REDUCED
0913	SMOKE NEARLY GONE, SLIGHT CHARRED SMELL
0914	NO SMOKE, SLIGHT CHARRED SMELL
0915	NO SMOKE, NORMAL EXHAUST SMELL (NO SMOKE)
0915	TEST #3 COMPLETED

SAMPLE #4

OE1 - WPUD001

Data Sheet DS002

Date: AUG 19 1987

5.4 Preliminary Status

TIME	INLET T_1 °F		T_2 °F		$T_{ambient}$, °F
0918	865		800		88

Verified LORD Date AUG 19 1987

5.2 Waste Sample:

Sample #4 TOTAL WEIGHT: 16 oz

Description: CANNED CHUNK STYLE DOG FOOD
5 SQUARES 2 PLY TOILET TISSUE
WATER

weight: Solid: 7½ oz
Liquid: 8 oz
Bag: ½ oz

WITH WPU @ T_1= 850±25°F, SAMPLE #4 WAS PUT IN TO SEE IF WDP DRUM WAS COOL ENOUGH TO PREVENT BAG DAMAGE. AFTER INSERTION, T_1 WAS RAISED TO 1000° + 0° -25°

Verified LORD Date AUG 19 1987

5.3 Response to Waste Insertion (use video system also)

TIME	T_1, °F	T_2, °F			$T_{ambient}$, °F
0918	920	700			74
0919	960	700			74
0920	990	760			74
0925	995	790			74
0930	1000	815			75
0935	1000	865			75
0940	1000	895			76
0945	1000	920			76
0950	1000	940			76
0953	1000	945			78
0954	1000	945			78

0954 TEST #4 COMPLETED

Verified LORD Date AUG 19 1987

Description of Effluents :

5.5 Description of WPUBM001 interior and contents: SAME AS WITH ONLY ONE SAMPLE

SAMPLE #3 & #4 B-16

Weight of contents: < 1 oz

SAMPLE #4

OEI - WPUD001

Data Sheet DS002 (cont.)

Date: AUG 19 1987

5.6 Effluent Description:

weight: 1 oz (SAMPLES 3&4)

0918 SAMPLE #4 INTO WDP & ROTATE LOTS OF SMOKE IMMEDIATELY
DRUM OK- SAMPLE DID NOT STICK, AND BAG APPARENTLY DID NOT MELT IN DRUM
0923 SMALL AMOUNT OF SMOKE & CHARRED SMELL
0927 NORMAL AMOUNT OF SMOKE & CHARRED SMELL
0928 NO VISIBLE LEAKS AROUND WDP DRUM
0935 NORMAL AMOUNTS OF SMOKE & charred smell
0942 NO CHANGE
0945 SMOKE DIMINISHING, AS WELL AS SMELL
0948 VERY LITTLE SMOKE, SOME SMELL
0950 NO SMOKE, VERY SLIGHT SMELL
0953 NO SMOKE, NO SMELL (NORMAL EXHAUST SMELL)
0954 SHUT DOWN TEST STAND TEST #4 COMPLETED

OEI - WPUD001

Data Sheet DS003

Date: AUG 19 1987

5.8 Observation, Results, Conclusions:

Insertion of samples #1, 2, & 3 was with the WPU at ambient temperature. Sample #4 was inserted with the WPU at operating temperature. No problems were found with either operational scenario.

The WDP does not seal completely when in the "down" position - suggest operational and control features be added to require WDP to be in the "UP" position when exhaust flow is ON thru the WPU.

APPENDIX C

MARINE WPU DEVELOPMENT UNIT TEST

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ENGINEERING DEVELOPMENT TEST:

WASTE PROCESSING UNIT DEVELOPMENT TEST PROCEDURE

#OEI - WPUD001

TEST DATE: 11-5-87

TEST CONDUCTOR: Jim Shirley

APPROVAL: [signature] DATE: 12-1-87
Principal Investigator

OEI - WPUD001

Purpose

The purpose of this Engineering Development Test is to determine specific parameters pertinent to the performance of the Marine Waste Processing Unit (Marine WPU) currently under development. Certain performance characteristics can best be determined by the experimental process. These include operating temperatures within the Marine WPU, effects of insulation on internal temperatures, seal performance, minimum operational inlet temperature, average cycle time as a function of inlet temperature, etc. Of particular interest for this test is the presence or absence of objectional odor during the processing cycle. It has been determined analytically that most objectionable odors should be eliminated by placing the WPU exhaust under water. The primary purpose of this test is to verify that analysis.

OEI - WPUD001

EQUIPMENT/MATERIALS REQUIRED

QTY	ITEM	I.D. NUMBER	
1	WPU TEST STAND		
1	EFFLUENT RETRIEVAL UNIT	(not assigned)	
1	WPU DEVELOPMENT UNIT (with adaptor inlet and outlet pipes)	#WPU-BM001 8611TAC0100-009	
1	TEMPERATURE PROBE: 200°-1000°F (2.5" Lg.)	#1	CAL Verified: NOV 0 5 1987
1	TEMPERATURE PROBE: 200°-1000°F (4.5" Lg.)	#2	#2 CAL Verified: NOV 0 5 1987
A/R	Waste samples, sealed in plastic bags		
1	Thermometer, -20°F to +100°F, for recording ambient temperature		

Documents Required

1	Engineering Test Procedure #OEI-WPUD001 (with data sheets)
1	Operational Procedures, WPU Test Stand (OP8611000)

MARINE

OEI - WPUD001

TEST PROCEDURE

1.0 Following calibration of temperature probes, install temperature probes into WPU Development Unit 8611MAR0100-009 .

Verified LORD Date NOV 0 5 1987

2.0 Install Development Unit onto WPU Test Stand using sections of pipe provided.

Verified LORD Date NOV 0 5 1987

3.0 Activate WPU Test Stand and adjust for an inlet temperature of 850±25°F. Once steady state conditions have been reached, flush toilet on Marine WPU (no sample- water only) and record response of system.

TIME	RPM	T_1, °F	T_2, °F	TIME		$T_{ambient}$, °F
	2000	550	260	0955		63
	2000	710	450	1000		64
	2000	850	600	1005		64
	2200	850	600	1007		64
	2200	920	660	1009		64
		940	200	1009	FLUSHE TOILET _ NO	SAMPLE
		940	200	1010		64
		940	500	1011		64
		940	650	1012		64

Verified LORD Date NOV 0 5 1987

4.0 Turn WPU Test Stand off and allow unit to return to ambient temperature .

Verified LORD Date NOV 0 5 1987

OEI - WPUD001

Data Sheet DS003

Date: NOV 0 5 1987

5.8 Observation, Results, Conclusions:

1000 MAIN WASTE PIPE STILL COOL TO THE TOUCH
TEMP T_2 WENT BELOW 200°F FOR APPROX. 45 SEC. WHEN FLUSHED
INLET TEMP REMAINED AT 940°F
CONSIDERABLE STEAM FROM EXHAUST IMMEDIATELY AFTER FLUSH.

MARINE

OEI - WPUD001

Data Sheet DS002

Date: NOV 0 5 1987

5.4 Preliminary Status

TIME	INLET T_1 °F		T_2 °F		$T_{ambient}$, °F
1029	850		650		58

Verified LORD Date NOV 0 5 1987

5.2 Waste Sample:

Sample #1 weight: Solid: UNK

Liquid: UNK

Description: Human fecal matter & urine
4 squares 2 ply toilet tissue
flush water

Bag: 0

Verified LORD Date NOV 0 5 1987

5.3 Response to Waste Insertion (use video system also)

TIME	T_1, °F	T_2 °F			$T_{ambient}$, °F
1030	850	<200			58
1032	900	<200			58
1033	900	<200			58
1034	950	450			58
1035	950	550			58
1036	960	620			58
1037	950	630			58
1038	970	660			58
1050	950	740			58
1100	950	770			58
1105	955	760			58
1112	955	750			58

Verified LORD Date NOV 0 5 1987

Description of Effluents : OTHER THAN STEAM IMMEDIATELY AFTER FLUSH, NO EFFLUENT FOUND. EFFLUENT FROM EXHAUST APPEARED TO BE ONLY STEAM AND CLEAR WATER (SLIGHTLY DISCOLORED)

5.5 Description of WPUBM001 interior and contents: MINUTE AMOUNT OF DRY BLACK ASH

Weight of contents: ~0 oz

OEI - WPUD001

Data Sheet DS003

Date: NOV 0 5 1987

5.8 Observation, Results, Conclusions:

1030 STEAM RISING FROM EFFLUENT RETRIEVAL UNIT (EXHAUST IS UNDER WATER)
1033 REFLUSHED TOILET
1034 NO ODOR, NO SMOKE
1035
1036
1037
1038
1050
1100
1105
1112 NO ODOR, NO SMOKE

Results of this test indicate that exhausting the WPU below the water line effectively eliminates smoke and odor from the unit.

Due to the possibility of exhaust pressure entering the waste pipe when an insufficient amount of water is in the "P" trap of the system, it is recommended that a counterweighted check valve be installed in the WPU at the Waste inlet.

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